US009175572B2

(12) **United States Patent**
McMurray et al.

(10) **Patent No.: US 9,175,572 B2**
(45) **Date of Patent: Nov. 3, 2015**

(54) **TURBOMACHINE BLADE MOUNTING SYSTEM**

(75) Inventors: **Timothy Scott McMurray**, Fultonville, NY (US); **Thomas Joseph Farineau**, Schoharie, NY (US)

(73) Assignee: **General Electric Company**, Schenectady, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 728 days.

(21) Appl. No.: **13/448,238**

(22) Filed: **Apr. 16, 2012**

(65) **Prior Publication Data**

US 2013/0272885 A1 Oct. 17, 2013

(51) **Int. Cl.**
F01D 5/14 (2006.01)
F01D 5/30 (2006.01)

(52) **U.S. Cl.**
CPC ***F01D 5/3038*** (2013.01); *F01D 5/147* (2013.01)

(58) **Field of Classification Search**
CPC F01D 5/3023; F01D 5/303; F01D 5/3038
USPC .... 416/204 R, 204 A, 215, 219 R, 220 R, 416/248
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,292,900	A *	12/1966	Pettersen	416/218
4,094,615	A *	6/1978	Glenn	416/215
4,684,325	A *	8/1987	Arnold	416/215
6,030,178	A	2/2000	Caruso	
6,619,924	B2 *	9/2003	Miller	416/220 R
6,647,602	B2 *	11/2003	Bachofner et al.	29/23.51
7,972,113	B1 *	7/2011	Davies	416/214 A
8,727,730	B2 *	5/2014	Liotta et al.	416/193 A
8,740,573	B2 *	6/2014	Delvaux et al.	416/248

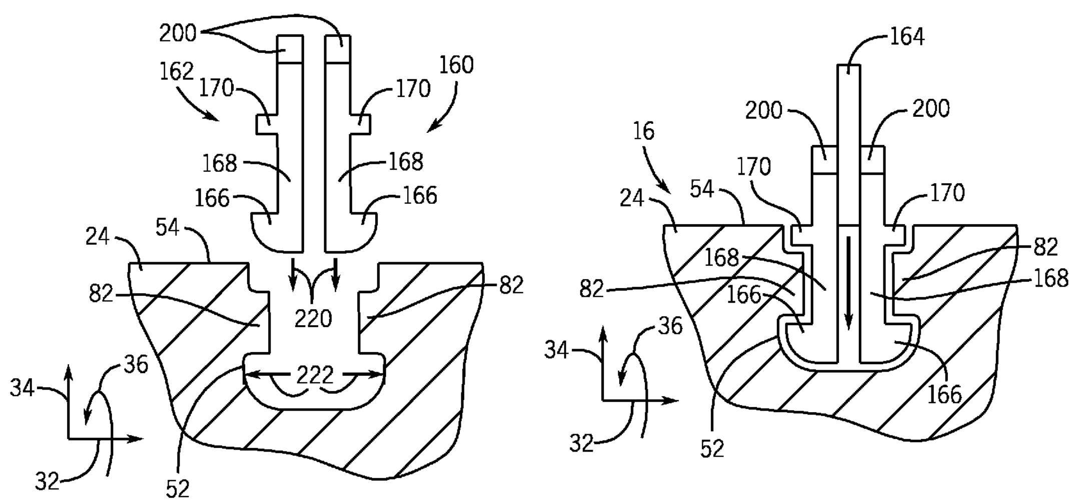
* cited by examiner

Primary Examiner — Edward Look
Assistant Examiner — Justin Seabe
(74) *Attorney, Agent, or Firm* — Fletcher Yoder, P.C.

(57) **ABSTRACT**

Embodiments of the present disclosure include a system having a turbine blade segment having a blade and a mounting segment coupled to the blade, wherein the mounting segment has a multi-piece assembly configured to mount in a radial direction into a slot of a turbomachine rotor.

6 Claims, 6 Drawing Sheets



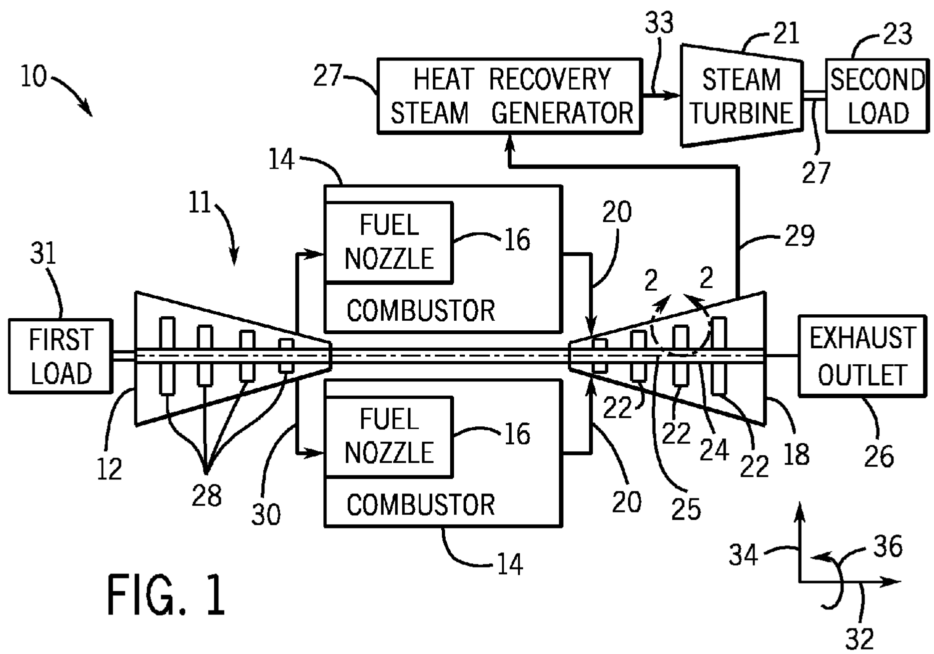

10
11
31
FIRST LOAD
12
28
30
14
FUEL NOZZLE
16
COMBUSTOR
27
HEAT RECOVERY STEAM GENERATOR
33
21
STEAM TURBINE
23
SECOND LOAD
27
29
20
2
2
22
22
24
22
25
18
EXHAUST OUTLET
26
34
36
32

FIG. 1

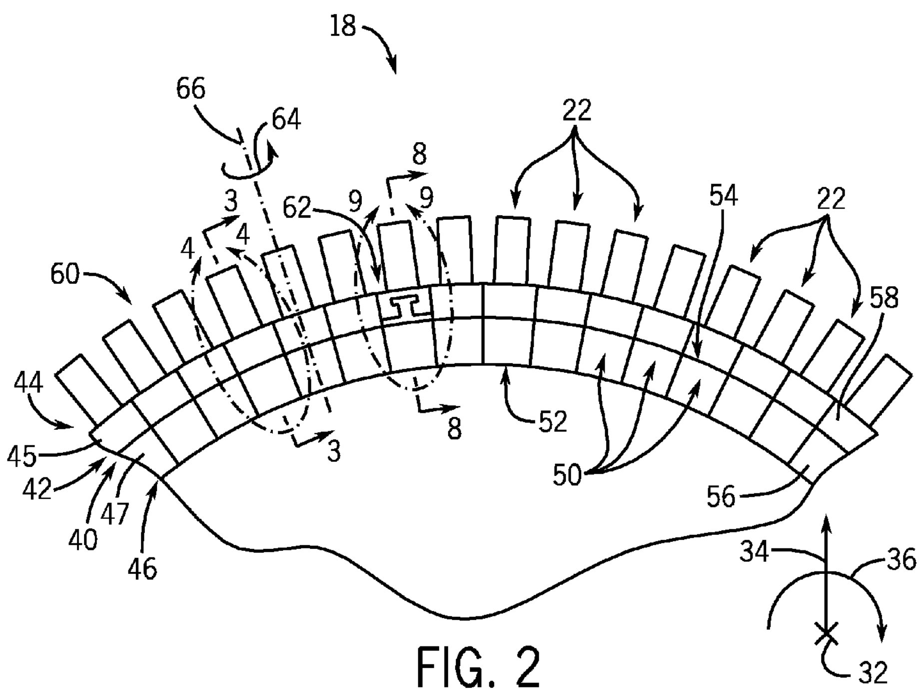

18
66
64
3
4
4
62
9
8
9
22
54
22
60
58
44
45
42
47
40
46
3
8
52
50
56
34
36
32

FIG. 2

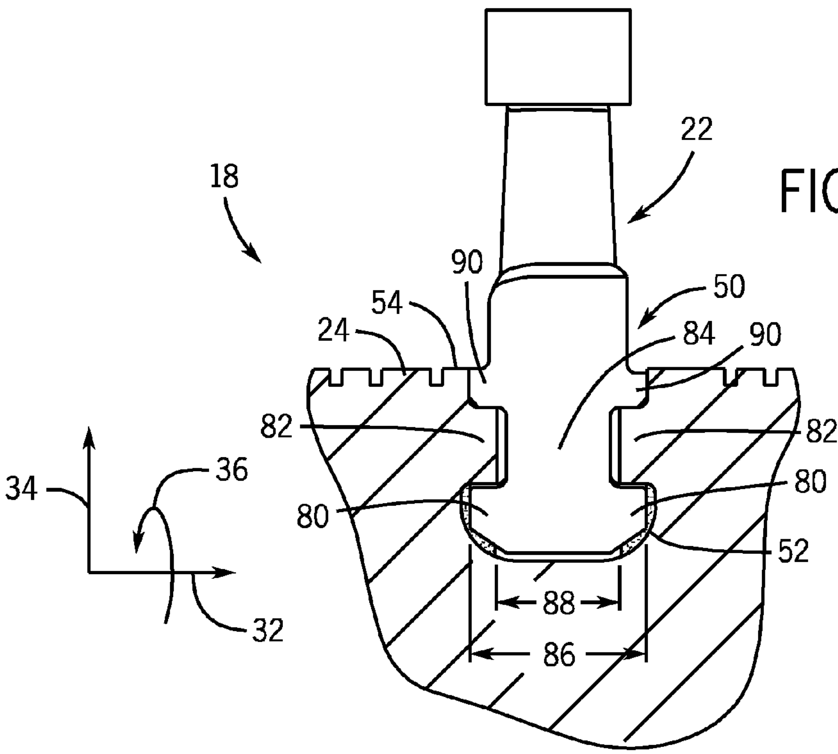

22
18
90
50
54
84
90
24
82
82
80
34
36
80
52
88
32
86

FIG. 3

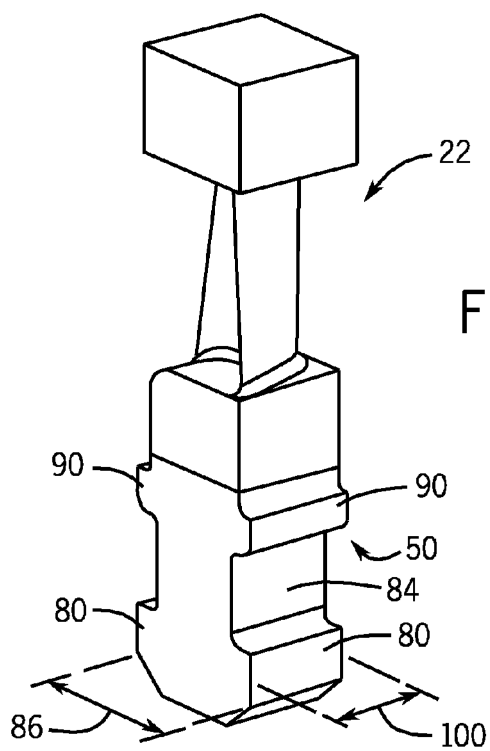

22
90
90
50
84
80
80
86
100

FIG. 4

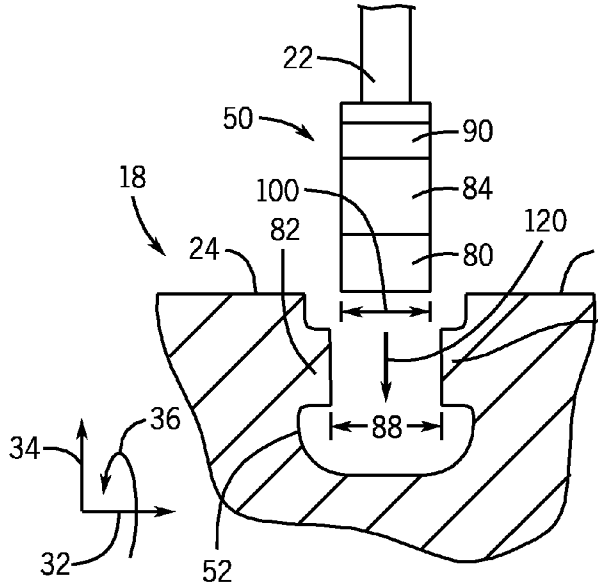
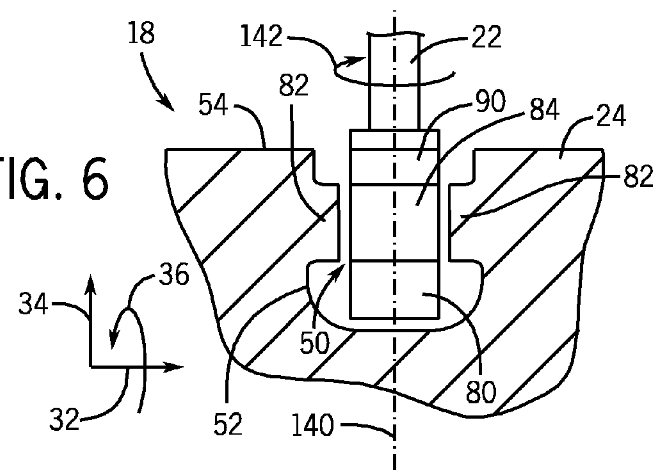


FIG. 5

FIG. 6



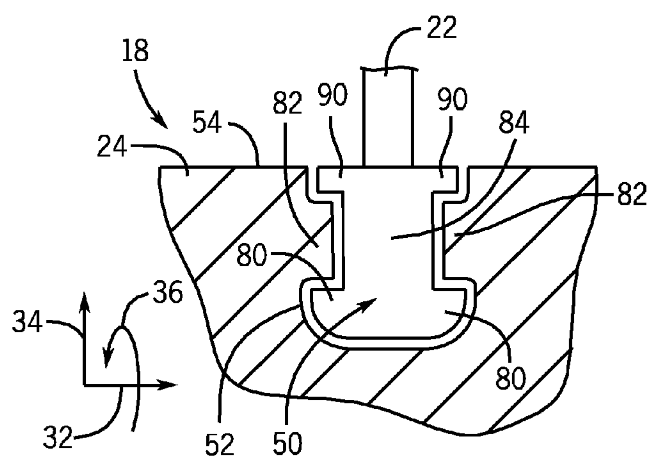


FIG. 7

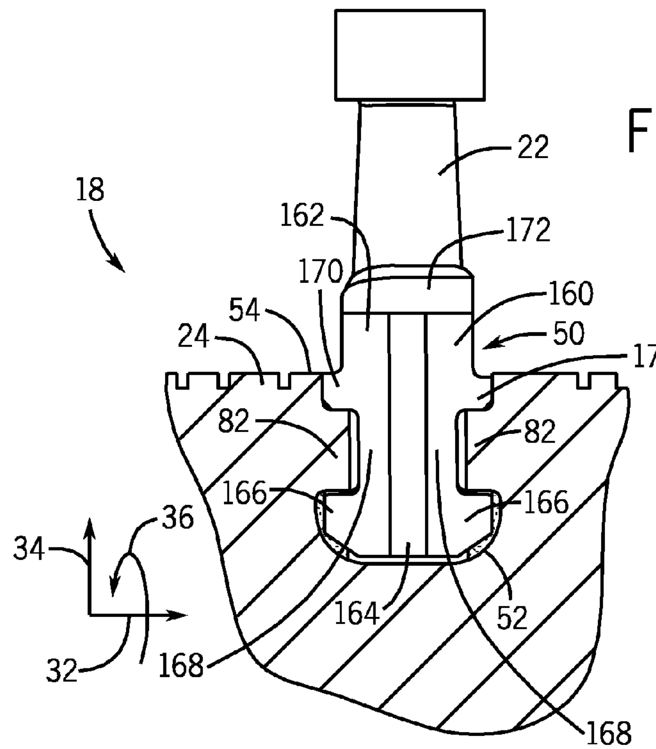

22
18
162
172
62
170
160
54
50
24
170
82
82
166
166
36
34
164
52
32
168
168

FIG. 8

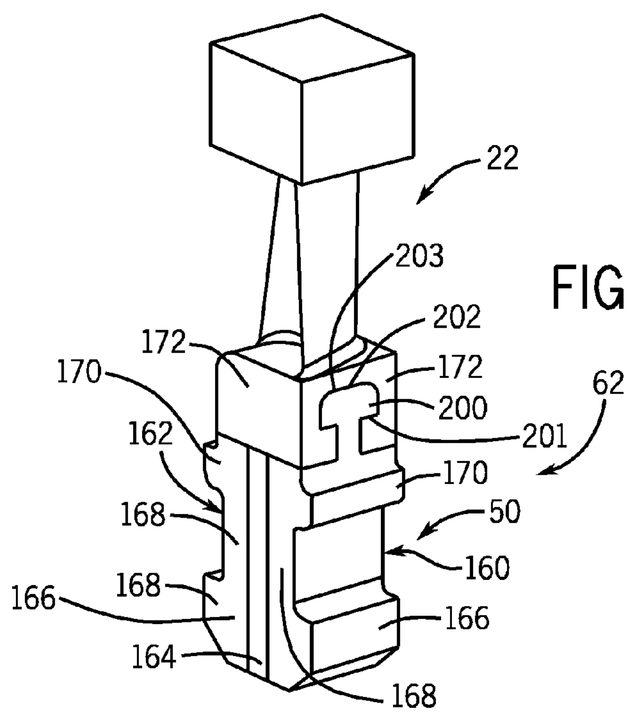

22
203
202
172
172
170
200
201
62
162
170
168
50
160
168
166
166
164
168

FIG. 9

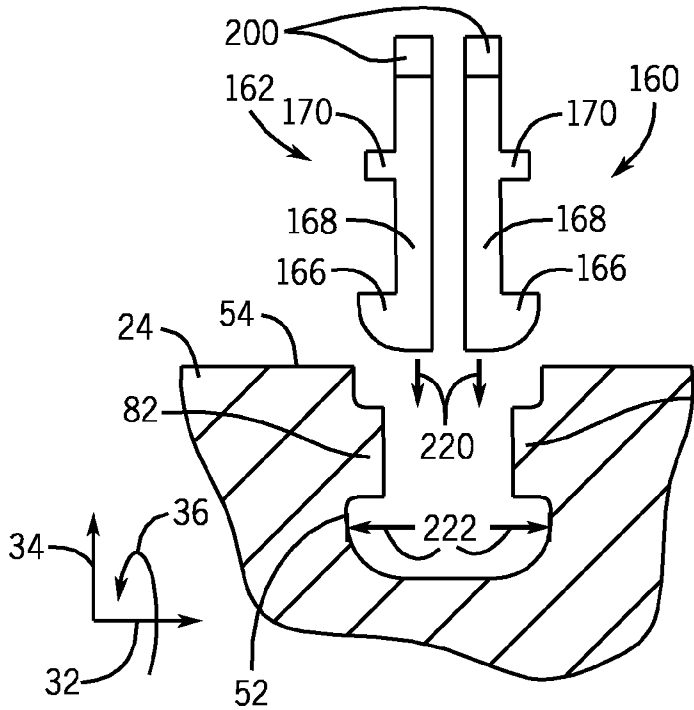

200
162
170
170
160
168
168
166
166
24
54
82
82
220
222
34
36
32
52

FIG. 10

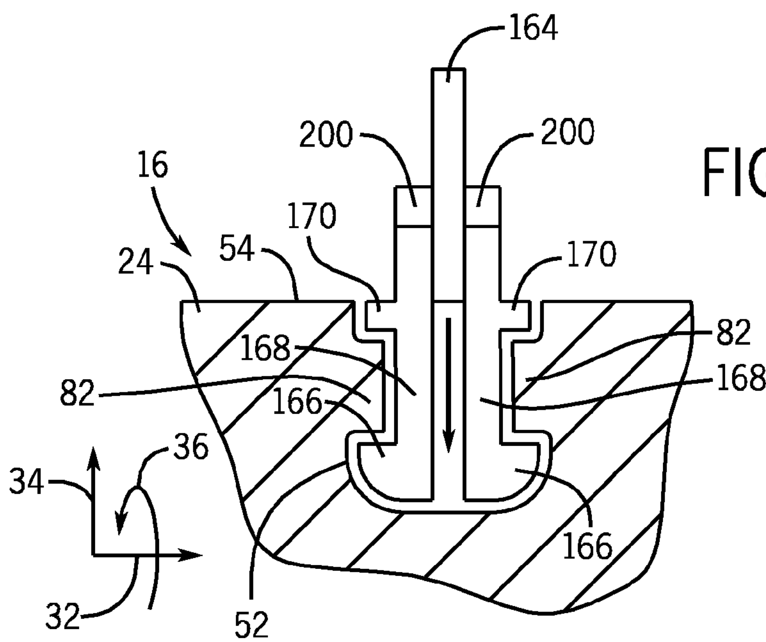

164
200
200
16
170
54
170
24
82
168
82
168
166
34
36
166
32
52

FIG. 11

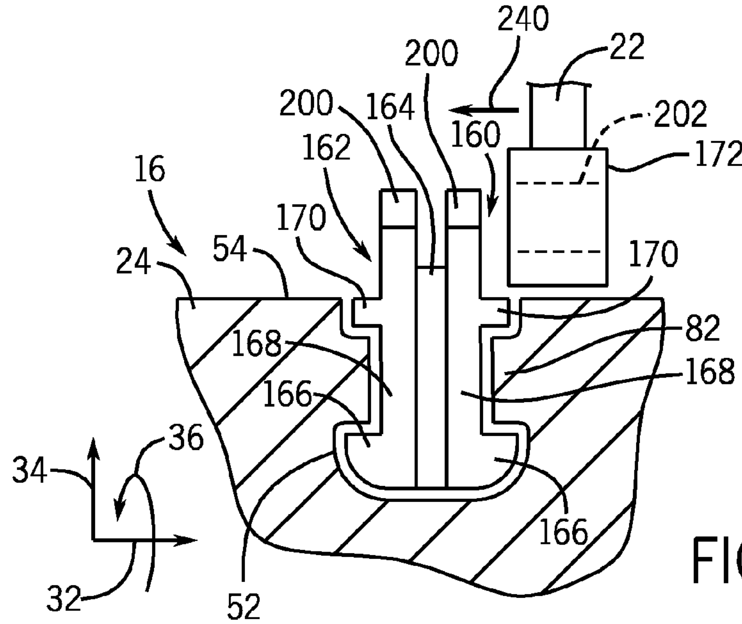

240
200
22
200
164
202
162
160
172
16
170
54
24
170
82
168
168
166
36
34
166
32
52

FIG. 12

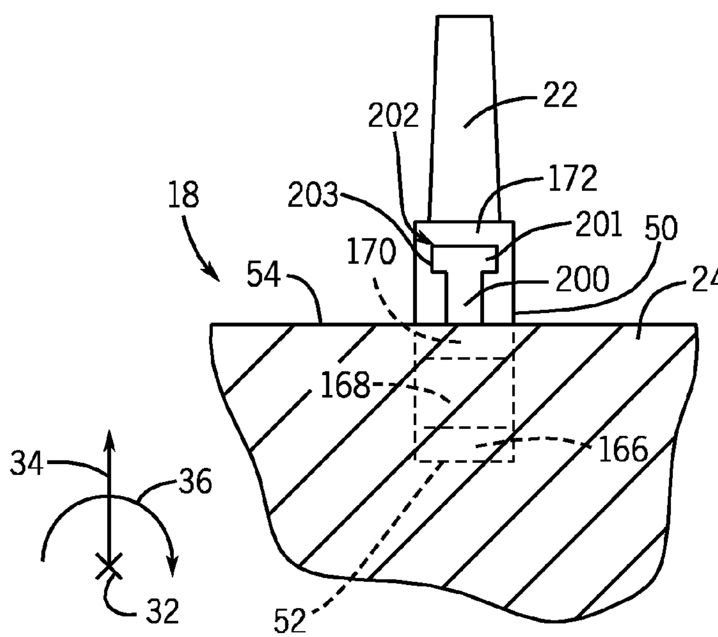

22
202
172
203
18
201
50
170
54
200
24
168
166
34
36
32
52

FIG. 13

TURBOMACHINE BLADE MOUNTING SYSTEM

BACKGROUND OF THE INVENTION

The subject matter disclosed herein relates to turbomachines, and, more particularly, to mounting systems for attaching turbomachine blades to a turbomachine rotor.

Turbomachines include compressors and turbines, such as gas turbines, steam turbines, and hydro turbines. Generally, turbomachines include a rotor, which may be a shaft or drum, which support turbomachine blades. For example, the turbomachine blades may be attached to the rotor by a mounting segment, which mates with a slot in the rotor. Unfortunately, the slot may not permit direct insertion into the slot due to retention features of the one-piece mounting segment and the slot. For example, the one-piece mounting segment may include lateral hooks, which cannot pass into the slot in a radial direction. As a result, the slot requires an assembly gate, such as an enlarged opening, configured to receive the mounting segments during turbomachine blade installation. Unfortunately, assembly gates can increase costs, create stress concentrations in the turbomachine rotor, and prolong turbine start times.

BRIEF DESCRIPTION OF THE INVENTION

Certain embodiments commensurate in scope with the originally claimed invention are summarized below. These embodiments are not intended to limit the scope of the claimed invention, but rather these embodiments are intended only to provide a brief summary of possible forms of the invention. Indeed, the invention may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

In a first embodiment, a system includes a turbomachine blade segment having a blade and a mounting segment coupled to the blade, wherein the mounting segment has a multi-piece assembly configured to mount in a radial direction into a slot of a turbomachine rotor.

In a second embodiment, a system includes a turbomachine blade mounting segment having first and second configurations, wherein the first configuration is configured to insert in a radial direction into a slot of a turbomachine rotor, and the second configuration is configured to expand relative to the first configuration to retain the turbomachine blade mounting segment in the slot.

In a third embodiment, a system includes a first turbomachine blade mounting segment configured to couple a first turbomachine blade to a turbomachine rotor and a second turbomachine blade mounting segment configured to couple a second turbomachine blade to the turbomachine rotor. Additionally, the first and second turbomachine blade mounting segments are configured to insert in a radial direction into a slot of the turbomachine rotor, and then expand in the slot.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

FIG. **1** is a schematic of an embodiment of a combined cycle power generation system having a gas turbine system, a steam turbine, and a heat recovery steam generation (HRSG) system.

FIG. **2** is a partial cross-sectional axial view of a turbomachine, illustrating circumferentially mounted turbomachine blades having mounting segments, in accordance with embodiments of the present disclosure;

FIG. **3** is a partial cross-sectional circumferential view of a turbomachine, illustrating a circumferentially mounted turbomachine blade having a mounting segment, in accordance with embodiments of the present disclosure;

FIG. **4** is a perspective view of a turbomachine blade having a mounting segment, in accordance with embodiments of the present disclosure;

FIG. **5** is a partial cross-sectional circumferential view of a turbomachine, illustrating installation of a turbomachine blade having a mounting segment, in accordance with embodiments of the present disclosure;

FIG. **6** is a partial cross-sectional circumferential view of a turbomachine, illustrating installation of a turbomachine blade having a mounting segment, in accordance with embodiments of the present disclosure;

FIG. **7** is a partial cross-sectional circumferential view of a turbomachine, illustrating installation of a turbomachine blade having a mounting segment, in accordance with embodiments of the present disclosure;

FIG. **8** is a partial cross-sectional circumferential view of a turbomachine, illustrating installation of a turbomachine blade having a multi-piece mounting segment, in accordance with embodiments of the present disclosure;

FIG. **9** is a partial perspective view of a turbomachine blade having a multi-piece mounting segment, in accordance with embodiments of the present disclosure;

FIG. **10** is a partial cross-sectional circumferential view of a turbomachine, illustrating installation of a turbomachine blade having a multi-piece mounting segment, in accordance with embodiments of the present disclosure;

FIG. **11** is a partial cross-sectional circumferential view of a turbomachine, illustrating installation of a turbomachine blade having a multi-piece mounting segment, in accordance with embodiments of the present disclosure;

FIG. **12** is a partial cross-sectional circumferential view of a turbomachine, illustrating installation of a turbomachine blade having a multi-piece mounting segment, in accordance with embodiments of the present disclosure; and

FIG. **13** is a partial axial view of a turbomachine, illustrating installation of a turbomachine blade having a multi-piece mounting segment, in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

When introducing elements of various embodiments of the present invention, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements.

The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

The disclosed embodiments include a turbomachine blade mounting segment (e.g., a first dovetail portion of a dovetail joint) for coupling a turbomachine blade to a drum rotor of a turbomachine, wherein the mounting segment (e.g., a first dovetail portion of a dovetail joint) is configured to mount the turbomachine blade to the rotor or drum without an assembly gate. For example, the mounting segment (e.g., a first dovetail portion of a dovetail joint) may be configured to engage with a retaining slot or recess (e.g., a second dovetail portion of a dovetail joint) of the turbomachine drum or rotor. In certain embodiments, the mounting segment (e.g., a first dovetail portion of a dovetail joint) may be configured to insert radially into the retaining slot or recess (e.g., a second dovetail portion of a dovetail joint) and subsequently rotate within the retaining slot or recess to engage retention features (e.g., hooks). Upon rotation, lateral extensions or hooks of the mounting segment (e.g., a first dovetail portion of a dovetail joint) may engage with retaining ledges of the retaining slot or recess (e.g., a second dovetail portion of a dovetail joint), thereby securing the mounting segment (e.g., a first dovetail portion of a dovetail joint) within the retaining slot or recess (e.g., a second dovetail portion of a dovetail joint). In other embodiments, the mounting segment (e.g., a first dovetail portion of a dovetail joint) may have a segmented or multi-piece configuration. For example, multiple pieces of a mounting segment (e.g., a first dovetail portion of a dovetail joint) may be inserted into the retaining slot or recess (e.g., a second dovetail portion of a dovetail joint) of the turbomachine drum or rotor individually. Furthermore, the multiple pieces of the mounting segment (e.g., a first dovetail portion of a dovetail joint) may be coupled to one another by an additional piece of the mounting segment once they are positioned within the retaining slot or recess (e.g., a second dovetail portion of a dovetail joint) of the turbomachine. While the embodiments disclosed below are described in the context of a turbine (e.g., steam, water, or gas turbine), it is important to note that the disclosed mounting segments (e.g., first dovetail portions of dovetail joints) may be used with other turbomachines, such as compressors.

Turning now to the drawings, FIG. **1** is a schematic block diagram of an embodiment of a combined cycle system **10** having various turbomachines that are equipped with improved blade mounting systems (e.g., dovetail joints). Specifically, the turbomachines include turbomachine blades with improved mounting segments (e.g., a first dovetail portion of a dovetail joint), which may be couple to a slot or recess (e.g., a second dovetail portion of a dovetail joint) or a rotor in a radial direction without requiring an assembly gate (e.g., enlarged opening). As shown, the combined cycle system **10** includes a gas turbine system **11** having a compressor **12**, combustors **14** having fuel nozzles **16**, and a gas turbine **18**. The fuel nozzles **16** route a liquid fuel and/or gas fuel, such as natural gas or syngas, into the combustors **14**. The combustors **14** ignite and combust a fuel-air mixture, and then pass hot pressurized combustion gases **20** (e.g., exhaust) into the gas turbine **18**. The turbine blades **22** are coupled to a rotor **24**, which is also coupled to several other components throughout the combined cycle system **10**, as illustrated. For example, the turbine blades **22** may be coupled to the rotor **24** with improved mounting segments, as discussed below. As the combustion gases **20** pass through the turbine blades **22** in the gas turbine **18**, the gas turbine **18** is driven into rotation, which causes the rotor **24** to rotate along a rotational axis **25**. Eventually, the combustion gases **20** exit the gas turbine **18** via an exhaust outlet **26** (e.g., exhaust duct, exhaust stack, silencer, etc.).

In the illustrated embodiment, the compressor **12** includes compressor blades **28**. The compressor blades **28** within the compressor **12** are also coupled to the rotor **24** (e.g., with improved mounting segments), and rotate as the rotor **24** is driven into rotation by the gas turbine **18**, as described above. As the compressor blades **28** rotate within the compressor **12**, the compressor blades **28** compress air from an air intake into pressurized air **30**, which is routed to the combustors **14**, the fuel nozzles **16**, and other portions of the combined cycle system **10**. The fuel nozzles **16** then mix the pressurized air and fuel to produce a suitable fuel-air mixture, which combusts in the combustors **14** to generate the combustion gases **20** to drive the turbine **18**. Further, the rotor **24** may be coupled to a first load **31**, which may be powered via rotation of the rotor **24**. For example, the first load **31** may be any suitable device that may generate power via the rotational output of the combined cycle system **10**, such as a power generation plant or an external mechanical load. For instance, the first load **31** may include an electrical generator, a propeller of an airplane, and so forth.

The system **10** also includes a steam turbine **21** for driving a second load **23** (e.g., via rotation of a shaft **27**). The second load **23** may also be an electrical generator for generating electrical power. However, both the first and second loads **31** and **23** may be other types of loads capable of being driven by the gas turbine system **11** and the steam turbine **21**. In addition, although the gas turbine system **11** and the steam turbine **21** drive separate loads (e.g., first and second loads **31** and **23**) in the illustrated embodiment, the gas turbine system **11** and steam turbine **23** may also be utilized in tandem to drive a single load via a single shaft.

The system **10** further includes the HRSG system **27**. Heated exhaust gas **29** from the turbine **18** is transported into the HRSG system **27** to heat water to produce steam **33** used to power the steam turbine **21**. As will be appreciated, the HRSG system **27** may include various economizers, condensers, evaporators, heaters, and so forth, to generate and heat the steam **33** used to power the steam turbine **21**. The steam **33** produced by the HRSG system **27** passes through turbine blades of the steam turbine **21**. As the steam **33** pass through the turbine blades in the steam turbine **21**, the steam turbine **21** is driven into rotation, which causes the shaft **27** to rotate, thereby powering the second load **23**.

In the following discussion, reference may be made to various directions or axes, such as an axial direction **32** along the axis **25**, a radial direction **34** away from the axis **25**, and a circumferential direction **36** around the axis **25** of the steam turbine **21**. Additionally, as mentioned above, while the mounting segments (e.g., a first dovetail portion of a dovetail joint) described below may be used with any of a variety of turbomachines (e.g., compressors **12**, gas turbines **18**, or steam turbines **21**) the following discussion describes improved mounting segments (e.g., a first dovetail portion of a dovetail joint) in the context of the turbine **21** (e.g., a steam turbine).

FIG. **2** is a partial cross-sectional axial view of the turbine **18** with the turbine blades **22** coupled to the rotor **24**, illustrating mounting assemblies or joints **40** (e.g., dovetail joints **42**), which couple the turbine blades **22** to the rotor **24**. Each mounting joint **40** includes a first joint portion **44** (e.g., a first dovetail portion **45**) disposed on each blade **22**, and a second joint portion **46** (e.g., a second dovetail portion **47**) disposed on the rotor **24**. For example, the first joint portion **44** (e.g., first dovetail portion **45**) may be a male joint portion (e.g., male dovetail portion) and the second joint portion **46** (e.g., second dovetail portion **47**) may be a female joint portion (e.g., female dovetail portion), or vice versa. In the illustrated embodiment, the first joint portion **44** (e.g., dovetail portion **45**) comprises a mounting segment **50** that is male, and the second joint portion **46** (e.g., dovetail portion **47**) comprises a recess or slot **52** that is female. Specifically, the mounting segments **50** are partially disposed within the slot **52** (e.g., a circumferential slot) formed in an outer surface **54** of the rotor **24**. For example, the slot **52** may extend in the circumferential direction **36** completely around (e.g., encircling) the rotor **24**. As illustrated, a first portion **56** of each mounting segment **50** is disposed within the slot **52** of the rotor **24**, while a second portion **58** of each mounting segment **50** extends radially **34** outward from the outer surface **54** of the rotor **24** and is coupled to the respective turbine blade **22**.

The illustrated embodiment shows a single stage **60** of turbine blades **22** coupled to the rotor **24**. As used herein, a "stage" of turbine blades **22** refers to those turbine blades **22** extending circumferentially **36** around the rotor **24** at a certain axial **32** location along the rotor **24**. Additionally, as mentioned above, the mounting segments **50** in the illustrated embodiment are circumferentially **36** mounted in the slot **52**. In other words, the slot **52** formed in the rotor **24** extends circumferentially **36** around the rotor **24**. As will be appreciated, the mounting segments **50** and their respective turbine blades **22** may be coupled to the rotor **24** by inserting the mounting segments **50** into the slot **52**. For example, as described in detail below, one or more of the mounting segments **50** may be installed by inserting the mounting segment **50** radially **34** into the slot **52** and subsequently twisting or rotating **64** the mounting segment **50** about its axis **66**, thereby engaging the mounting segment **50** with retaining ledges of the slot **52** to secure the turbine blade **22** to the rotor **24**. In this manner, the mounting segments **50** may be installed within the slot **52** without an assembly gate or other enlarged opening formed in the slot **52**. In other words, the slot **52** may be uniform circumferentially **36** about the rotor **24** (e.g., constant width of opening into slot **52**).

However, not all mounting segments **50** in the single stage **60** may be configured for radial **34** insertion and subsequent rotation **64**. As shown, the mounting segments **50** disposed within the slot **52** of the rotor **24** abut one another in the circumferential direction **36**. Specifically, each mounting segment **50** abuts the mounting segments **50** to which it is circumferentially **36** adjacent. As a result, once a certain number of mounting segments **50** of the single stage **60** are coupled to the rotor, there may not be adequate room for the radial **34** insertion and twisting **64** of additional mounting segments **50**. For example, when all but one mounting segment **50** of the single stage **60** of turbine blades **22** have been radially **34** inserted into the slot **52**, there may not be enough space or room to radially **34** insert and twist **64** the final mounting segment **50**. Therefore, the single stage **60** of turbine blades **22** may include one or more mounting segments **50** (e.g., mounting segment **62**) having a segmented or multi-piece configuration. As described in detail below, the multiple pieces of the mounting segment **50** having a multi-piece configuration (e.g., mounting segment **62**) may be radially **34** inserted into the slot **52** individually, arranged within the slot **52** to engage with the retaining ledges of the slot **52**, and coupled to one another. In this manner, the final mounting segment **50** of the single stage **60** (e.g., mounting segment **62**) may be radially **34** installed within the slot **52** without an assembly gate or other enlarged opening in the slot **52**. In other words, the slot **52** may be uniform circumferentially **36** about the rotor **24** (e.g., constant width of opening into slot **52**).

FIG. **3** is a partial cross-sectional circumferential view, taken along line **3-3** of FIG. **2**, of the turbine **18**, illustrating an embodiment of the turbine blade **22** and the mounting segment **50** circumferentially **36** mounted in the slot **52** around the rotor **24**. In the illustrated embodiment, the mounting segment **50** and the turbine blade **22** may be integrally formed. In other words, the mounting segment **50** and the turbine blade **22** may be a single piece. Furthermore, the mounting segment **50** is configured to be inserted radially **34** into the slot **52** of the rotor **24** and subsequently twisted or rotated, thereby engaging opposite hooks **80** of the mounting segment **50** with opposite retaining ledges **82** of the slot **52**. That is, the hooks **80** of the mounting segment **50** expand and radially **34** abut the retaining ledges **82** of the slot **52** after the mounting segment **50** is inserted radially **34** into the slot **52** and twisted or rotated within the slot **52**. More specifically, in the installed position shown, the hooks **80** extend laterally from a neck **84** of the mounting segment **50** along the axial **32** direction of the turbine **18** and on opposite sides from one another. The hooks **80** and the neck **84** of the mounting segment **50** combine to have a width **86**, while a width **88** extends between the retaining ledges **82** of the slot **52**. As the width **88** is less than the width **86**, the hooks **80** cause the mounting segment **50** to be radially **34** retained within the slot **52**, thereby securing the mounting segment **50** and the turbine blade **22** to the rotor **24**.

In the illustrated embodiment, the mounting segment **50** further includes anti-rotation ridges **90**. Specifically, the anti-rotation ridges **90** extend laterally from the neck **84** and on opposite sides of the mounting segment **50**. As shown, the anti-rotation ridges **90** are configured to be disposed within the slot **52** of the rotor **24** and are generally flush with the outer surface **54** of the rotor **24** when the mounting segment **50** is coupled to the rotor **24**. As will be appreciated, the anti-rotation ridges **90** may reduce rotation or pivoting of the mounting segment **50** within the rotor **24**, thereby increasing the stability and rigidity of the turbine blade **22**. In certain embodiments, the mounting segment **50** may not include anti-rotation ridges **90**.

FIG. **4** is a perspective view, taken within line **4-4** of FIG. **2**, of the turbine blade **22** and the mounting segment **50** having a single piece construction, where the mounting segment **50** is configured to be coupled to the rotor **24** by radially **34** inserting the mounting segment **50** into the slot **52** of the rotor **24** and rotating or twisting the mounting segment **50** within the slot **52**. As shown, the mounting segment **50** has a depth **100**, which is less than the width **88** (FIG. **3**) between the retaining ledges **82** of the slot **52** in the rotor **24**. In this manner, the mounting segment **50** may be radially **34** inserted into the slot **52** by orienting the segment **50** with the depth **100** between the retaining ledges **82** of the slot **52**. Thereafter, as described below, the mounting segment **50** may be rotated or twisted approximately 90 degrees within the slot **52**, thereby causing the hooks **80** of the mounting segment **50** to abut the retaining ledges **82** of the slot **52** (e.g., by orienting the segment **50** with the width **86** below the ledges **82**). In this manner, the mounting segment **50** may be secured within the slot **52** and the turbine blade **22** may be coupled to the rotor **24** without any assembly gate (e.g., enlarged opening in the slot **52**).

FIGS. **5-7** are schematics of the turbine blade **22** and the mounting segment **50**, illustrating the installation of the mounting segment **50** by radially **34** inserting the mounting segment **50** into the slot **52** of the rotor **24** and rotating or twisting the mounting segment **50** within the slot **52**. For example, FIG. **5** illustrates the manner in which the mounting segment **50** may be radially **34** inserted into the slot **52** of the rotor **24**. Specifically, in the illustrated configuration (e.g., a first configuration) of the mounting segment **50**, the depth **100** of the mounting segment **50** is less than the width between the retaining ledges **82** of the slot **52**. Therefore, in the manner illustrated, the mounting segment **50** may be radially **34** inserted into the slot **52** in the radial **34** direction, as indicated by arrow **120**. In this way, the mounting segment **50** may be radially **34** inserted into the slot **52** between the retaining ledges **82** of the slot **52** without any assembly gate (e.g., enlarged opening in the slot **52**).

Once the mounting segment **50** has been radially **34** inserted into the slot **52** of the rotor **24**, the mounting segment **50** may be rotated or twisted within the slot **52**, as illustrated by FIG. **6**. More particularly, the mounting segment **50** may be rotated or twisted about a longitudinal axis **140** of the mounting segment **50**, as indicated by arrow **142**, from the configuration shown in FIG. **5** (e.g., a first configuration) to the configuration shown in FIG. **7** (e.g., a second configuration). Furthermore, the mounting segment **50** may be rotated or twisted approximately 90 degrees. In this manner, the hooks **80** of the mounting segment **50** may rotate (e.g., expand) within the slot **52** and beneath the retaining ledges **82**. Once the mounting segment **50** has been rotated about the longitudinal axis **140** approximately 90 degrees, the hooks **80** of the mounting segment **50** engage with, and radially **34** abut, the retaining ledges **82** of the slot **52**, as shown in FIG. **7**. In this manner, the mounting segment **50** may be secured within the slot **52**, as the interface between the retaining ledges **82** and the hooks **80** of the mounting segment **50** blocks movement (e.g., movement in the radial **34** direction) of the mounting segment **50**, thereby securing the turbine blade **22** to the rotor **24**. Again, this radial **34** insertion and twisting **142** technique eliminates the need for an assembly gate, while also enabling installation of each blade **22** very close to its desired circumferential **36** position along the slot **52**, e.g., without requiring the blade to be moved circumferentially **36** along the slot **52** from an assembly gate to its desired circumferential position.

FIG. **8** is a partial cross-sectional circumferential view, taken within line **8-8** of FIG. **2**, of the turbine **18**, illustrating an embodiment of the turbine blade **22** and the mounting segment **50** circumferentially **36** mounted to the rotor **24**. In the illustrated embodiment, the mounting segment **50** has a multi-piece, or segmented, construction. In this manner, the mounting segment **50** may be installed in the slot **52** of the rotor **24** by inserting the multiple pieces individually and one at a time. For example, the assembled mounting segment **50** shown in FIG. **8** includes a first dovetail segment **160** (e.g., a forward or "gas/steam exit side" dovetail segment), a second dovetail segment **162** (e.g., a trailing or "gas/steam entrance side" dovetail segment), and a captured spreader piece **164**. As shown, in the assembled configuration, the captured spreader piece **164** is disposed between, or "captured" by, the first and second dovetail segments **160** and **162**. In one embodiment, the captured spreader piece **164** may be a rectangular plate. Additionally, in certain embodiments, the first and second dovetail segments **160** and **162** may have identical or similar configurations. For example, both the first and second dovetail segments **160** and **162** include a hook **166** extending laterally from a respective neck **168** of the first and second dovetail segments **160** and **162**. As similarly discussed above, the hooks **166** of the first and second dovetail segments **160** and **162** are configured to engage with one of the retaining ledges **82** of the slot **52**. Additionally, the first and second dovetail segments **160** and **162** also include an anti-rotation ridge **170** extending laterally from their respective necks **168**. As similarly discussed above, the anti-rotation ridges **170** are configured to be disposed within the slot **52** of the rotor **24** and are generally flush with the outer surface **54** of the rotor **24** when the first and second dovetail segments **160** and **162** are coupled to the rotor **24**. The anti-rotation ridges **170** may reduce rotation or pivoting of the mounting segment **50** within the rotor **24**, thereby increasing the stability and rigidity of the turbine blade **22**.

The mounting segment **50** in the illustrated embodiment further includes a cover portion **172**, which is integrated with the turbine blade **22**. In other embodiments, the cover portion **172** may not be integrated with the turbine blade **22**. As discussed in detail below, the cover portion **172** is configured to engage with the first and second dovetail segments **160** and **162**, thereby holding the first dovetail segment **160**, the second dovetail segment **162**, and the captured spreader piece **164** between the first and second dovetail segments **160** and **162** in place within the slot **52** of the rotor **24**. Specifically, once the first and second dovetail segments **160** and **162** and the captured spreader piece **164** are installed within the slot **52** of the rotor **24**, the cover portion **172** may be coupled to the first and second dovetail segments **160** and **162**, thereby securing the multiple pieces of the mounting segment **50** together and completing the installation of the mounting segment **50** and the turbine blade **22** with the rotor **24**. Again, this multi-piece construction of the final mounting segment **50** (e.g., **62**) enables installation of the final blade **22** without any assembly gate (e.g., enlarged opening) in the slot **52**.

FIG. **9** is a perspective view, taken within line **9-9** of FIG. **2**, of the turbine blade **22** and the mounting segment **50** having a multi-piece, or segmented, construction, where the mounting segment **50** is configured to be coupled to the rotor **24** by individually inserting the multiple pieces of mounting segment **50** radially **34** into the slot **52** of the rotor **24**. As mentioned above, the first and second dovetail segments **160** and **162** are configured to engage with the cover portion **172**, thereby securing the multiple components of the mounting segment **50** in the configuration shown below. Specifically, each of the first and second dovetail segments **160** and **162** have a rail **200** configured to engage with a retaining track or recess **202** of the cover portion **172**. In the illustrated embodiment, the rail **200** has a T-shaped protrusion **201**, which is received by, and engaged with, a T-shaped groove **203** of the retaining track **202** in the cover portion **172**. However, in other embodiments, the rail **200** and track **202** may have other geometries or configurations. As will be appreciated, the retaining track **202** is configured to match the geometry of the rail **200**, such that the rail **200** and the retaining track **202** interlock and block movement (e.g., radial **34** and circumferential **36**) of the components of the mounting segment **50**. In this manner, the mounting segment **50** may be secured within the slot **52**, and the turbine blade **22** may be coupled to the rotor **24**. Furthermore, in other embodiments, the captured spreader piece **164** may also have the rail **200** configured to engage with the retaining track **202**.

FIGS. **10-13** are schematics of the turbine blade **22** and the mounting segment **50**, illustrating the installation of the mounting segment **50** by radially **34** inserting the multiple components of the mounting segment **50** (e.g., the first and second dovetail segments **160** and **102** and the captured spreader piece **164**) into the slot **52** of the rotor **24** individually. Thereafter, the cover portion **172**, which may be integrated with the turbine blade **22**, may be coupled to the multiple components of the mounting segment **50**, thereby securing the mounting segment **50** within the slot **52** of the rotor **24**. For example, FIG. **10** illustrates the manner in which the first and second dovetail segments **160** and **102** of the mounting segment **50** may be radially **34** inserted into the slot **52** of the rotor **24**. Specifically, in the manner illustrated, the first and second dovetail segments **160** and **162** may be inserted into the slot **52** in the radial **34** direction, as indicated by arrows **220**. In the illustrated configuration (e.g., a first configuration), with the spreader piece **164** absent, the dovetail portions **160** and **162** (alone or together) are narrower than the width **88** between the opposite ledges **82**.

Once the first and second dovetail segments **160** and **162** have been inserted into the slot **52** of the rotor, the first and second dovetail segments **160** and **162** may be positioned (e.g., expanded) to be engaged with the retaining ledges **82** of the slot **52**. Specifically, as indicated by arrows **222**, the first and second dovetail portions **160** and **162** may be moved in opposite axial **32** directions (e.g., an upstream axial **32** direction and a downstream axial **32** direction), such that the hook **166** each dovetail portion **160** or **162** engages with a respective retaining ledge **82** of the slot **52**.

FIG. **11** illustrates the manner in which the captured spreader piece **164** of the mounting segment **50** may be positioned within the slot **52** of the rotor **24**. More specifically, after the first and second dovetail segments **160** and **162** are disposed within the slot **52** and engaged with respective retaining ledges **82**, the captured spreader piece **164** may be radially **34** inserted into the slot **52** between the first and second dovetail segments **160** and **162**. In this manner, the captured spreader piece **164** may help outwardly bias and hold the first and second dovetail segments **160** and **162** in position (e.g., in a second configuration), whereby the respective hooks **166** of the first and second dovetail segments **160** and **162** are engaged with respective retaining ledges **82** of the slot **52** of the rotor **24**.

FIG. **12** illustrates the manner in which the cover portion **172** of the mounting segment **50** may be coupled to the first and second dovetail segments **160** and **162**. As discussed above, the first and second dovetail segments **160** and **162** have the rails **200** (e.g., T-shaped protrusions **201**), which are configured to engage with the retaining track **202** (e.g., T-shaped groove **203**) of the cover portion **172** of the mounting segment **50**. For example, in the illustrated embodiment, the cover portion **172**, which is integrated with the turbine blade **22**, may be translated in the axial **32** direction, as indicated by arrow **240**. In this manner, the retaining track **202** of the cover portion **172** may be positioned about, and engaged with, the rails **200** of the first and second dovetail segments **160** and **162**, thereby securing the cover portion **172** to the first and second dovetail segments **160** and **162**. As a result, the components of the mounting segment **50** (e.g., the first and second dovetail segments **160** and **162**, the captured spreader piece **164**, and the cover portion **172**) may be held in place, and the mounting segment **50** of the turbine blade **22** may be assembled and coupled to the rotor **24**. For example, FIG. **13** is a partial cross-sectional axial view of the turbine **16**, illustrating the turbine blade **22** coupled to the rotor **24** by the mounting segment **50** having a multi-piece or segmented configuration.

The disclosed embodiments are directed towards improved mounting segments **50**, which may couple turbomachine blades (e.g., turbine blades **22**) to a turbomachine rotor or drum (e.g., rotor **24**) without the use of an assembly gate (e.g., enlarged opening in circumferential slot **52**). In other words, the disclosed embodiments may be used with a uniform circumferential slot **52**, which has a cross-section that is constant in the circumferential direction **36** about the rotor **24**. For example, the mounting segment **50** may be configured to insert radially **34** into the retaining slot **52** of the rotor **24**, and then subsequently rotate within the slot **52** at any position along the slot **52**. Upon rotation of the mounting segment **50**, hooks **80** of the mounting segment **50** may engage with retaining ledges **82** of the slot **52**, thereby securing the mounting segment **50** within the slot **52**. In other embodiments, the mounting segment **50** may have a segmented or multi-piece configuration, which enables mounting of the blade **22** at any position along the slot **52** without any assembly gate (e.g., enlarged opening) in the slot **52**. For example, multiple pieces (e.g., first and second dovetail segments **160** and **162** and captured spreader piece **164**) of the mounting segment **50** may be inserted into the slot **50** of the rotor **24** individually. Furthermore, the multiple pieces of the mounting segment **50** (e.g., first and second dovetail segments **160** and **162** and captured spreader piece **164**) may be coupled to the cover portion **172** of the mounting segment **50**, once the multiple pieces of the mounting segment **50** are positioned within the slot **52** of the rotor **24**. Moreover, while the embodiments discussed above are described in the context of a turbine **21** (e.g., a steam turbine), it is important to note that the disclosed mounting segments **50** may be used with other turbomachines, such as compressors.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

The invention claimed is:

1. A system, comprising:

a turbomachine rotor comprising a slot; and

a turbomachine blade mounting segment having first and second configurations, wherein the first configuration is configured to tangentially insert in a radial direction into the slot of the turbomachine rotor, and the second configuration is configured to expand relative to the first configuration to retain the turbomachine blade mounting segment in the slot, wherein the turbomachine blade mounting segment comprises a first dovetail segment, a second dovetail segment, a captured spreader piece, and a cover portion having a retention feature, the cover portion is configured to couple the first dovetail segment, the second dovetail segment, and the captured spreader piece to one another, and the first dovetail segment, the second dovetail segment, and the captured spreader piece are each configured to be individually inserted in the radial direction into the slot, and at least one portion of the turbomachine blade mounting segment is integrally formed with a turbomachine blade configured to be coupled to the turbomachine rotor by the turbomachine blade mounting segment.

2. The system of claim **1**, wherein the first and second dovetail segments each comprise hooks configured to pass between retaining ledges of the slot during insertion into the slot in the first configuration, and the hooks are configured to move into engagement with the retaining ledges of the slot in the second configuration.

3. The system of claim **2**, wherein the first configuration has first opposite sides configured to fit between the retaining ledges of the slot, the second configuration has second opposite sides with the hooks configured to overlap with the retaining ledges, the first and second opposite sides are oriented approximately 90 degrees relative to one another, and the second configuration is rotated approximately 90 degrees relative to the first configuration in the slot.

4. The system of claim **1**, comprising the turbomachine blade, and a turbomachine having the turbomachine rotor.

5. A system, comprising:

a first turbomachine blade mounting segment configured to couple only a first turbomachine blade to a turbomachine rotor; and

a second turbomachine blade mounting segment configured to couple only a second turbomachine blade to the turbomachine rotor,

wherein the first and second turbomachine blade mounting segments are configured to tangentially insert in a radial direction into a slot of the turbomachine rotor, and then expand in the slot, wherein the second turbomachine blade mounting segment comprises a first dovetail segment, a second dovetail segment, a spreader piece, and a cover portion having a retention feature, wherein the cover portion is configured to couple the first dovetail segment, the second dovetail segment, and the spreader piece to one another, wherein the first dovetail segment, the second dovetail segment, and the spreader piece are individually insertable in the radial direction into the slot of the turbomachine rotor to expand the second turbomachine blade mounting segment in the slot.

6. The system of claim **5**, wherein the first turbomachine blade mounting segment is configured to insert in the radial direction into the slot of the turbomachine rotor and then rotate about its axis to expand the first turbomachine blade mounting segment in the slot.

* * * * *